RADIX International Journal of Foundational Learning
https://journal.synrise.org/index.php/radix

e-ISSN : XXXX-XXX
Vol 1, Issue 1, 2026
pp. 1-6

A New Learning Taxonomy: Positioning AI in the Theoretical Landscape of 21st-Century Primary Education

Silviyani[1], Nur Aliah[2*]
[1] Pendidikan Guru Sekolah Dasar, Universitas Ahmad Dahlan, Yogyakarta Indonesia
[2] Psikologi Kanak-Kanak dan Keluarga, Universiti Malaysia Sabah, Kinabalu, Malaysia

*Corresponding author email: nuraliah.alias@student.ums.edu.my

Article Info

Article history:

Received: 19-11-2025
Revised: 21-12-2025
Accepted: 12-01-2026

Keywords:

Learning taxonomy, Artificial Intelligence, Primary Education, 21st-Century Skills, Educational Design

ABSTRACT

The pervasive integration of Artificial Intelligence (AI), particularly generative AI, into education has precipitated a paradigm shift that existing learning taxonomies are ill-equipped to address. Classical models like Bloom's revised taxonomy, conceived in a pre-digital era, fail to account for collaborative intellectual partnerships between humans and AI. This conceptual paper argues for the critical necessity of a new learning taxonomy that explicitly positions AI as a transformative agent in 21st-century primary education. Through critical synthesis of established taxonomies and contemporary learning theories, this article identifies theoretical gaps in AI-saturated learning environments and proposes a novel, multi-dimensional taxonomy comprising three interconnected dimensions: (1) The Cognitive-Metacognitive Dimension, expanding traditional hierarchies to include skills like evaluating AI outputs and strategic problem-solving; (2) The Human-AI Interaction Dimension, outlining competencies from basic prompting to advanced co-creation; and (3) The Ethical Dimension, integrating critical digital literacy concerning algorithmic bias and societal impact. The article illustrates this taxonomy's application in primary education contexts and discusses its profound implications for pedagogical practices, teacher roles—which shift from knowledge transmitters to ethical guides and learning architects—and assessment evolution toward process-oriented skills. This taxonomy serves as a crucial roadmap for fostering uniquely human capabilities through symbiotic human-AI collaboration, thereby equipping young learners for a complex future.

1. INTRODUCTION

The landscape of primary education in the 21st century is undergoing an unprecedented disruption, driven by the acceleration of digital technology and the emergence of easily accessible generative Artificial Intelligence (AI). The contemporary classroom is no longer a closed environment where the teacher is the sole authoritative source of knowledge. Instead, it has transformed into a dynamic learning network where students, even at the primary level, have begun to interact with intelligent non-human entities as part of their learning process (Zhai et al., 2021).

This development raises fundamental and urgent questions for educational theorists, policymakers, and practitioners: How do we define, classify, and ultimately assess learning in a context where machines can generate essays, solve complex mathematical problems, and create artistic content with a simple prompt? The central thesis of this conceptual article is that traditional learning taxonomies, with the revised Bloom's Taxonomy

How to cite: Silviyani & Aliah, N. (2025). A New Learning Taxonomy: Positioning AI in the Theoretical Landscape of 21st-Century Primary Education. *Radix: International Journal Foundational Learning*, *1*(1), 1–6. https://doi.org/10.55681/radix.v1i1.3

(Anderson & Krathwohl, 2001) as the most influential representative, have become inadequate for properly accommodating the forms of intelligence and learning mediated by AI (Chiu, 2023).

These classical models, designed in and for a pre-digital era, primarily focus on isolated individual cognitive processes. They operate on the implicit assumption that all intellectual work originates from and is generated exclusively by the human mind (Siemens, 2017). This assumption is now obsolete. Generative AI, such as Large Language Models (LLMs), has become a "cognitive partner" capable of performing many tasks at the "analyzing," "evaluating," and even "creating" levels as defined in the old taxonomy (Kasneci et al., 2023). Consequently, education that clings solely to this framework is at high risk of producing superficial "task-completion"—where students become passive AI operators—rather than fostering a deep "mastery of competencies" that prepares them for a complex life (Su & Yang, 2022).

The theoretical foundation for this concern can be traced through the evolution of learning taxonomies and 21st-century learning theories. The original Bloom's Taxonomy (Bloom et al., 1956) and its revision by Anderson & Krathwohl (2001), as well as Marzano's model (Marzano & Kendall, 2007), though highly meritorious, are fundamentally anthropocentric and do not provide the conceptual space to categorize the skills needed to collaborate effectively with a non-human intelligence (Ng et al., 2021). Meanwhile, contemporary learning theories such as Vygotsky's Social Constructivism (1978) can be expanded by viewing AI as a non-human "More Knowledgeable Other" (Roll & Wylie, 2016), and Connectivism (Siemens, 2005) provides a strong foundation by asserting that learning resides in networks that now include non-human intelligence nodes (Hwang et al., 2020). The evolution of AI's role in education from Computer-Assisted Instruction (Woolf, 2010) to a collaborative partner in complex problem-solving (Baker, 2016; Luckin, 2018) further solidifies the need for a new framework.

Therefore, this article introduces the urgent need for a new learning taxonomy not intended to replace the foundation built by the pioneers, but to integrate and expand it by explicitly incorporating the new dimensions that characterize cognition in the AI era: the dimension of human-AI interaction and collaboration, the dimension of critical digital ethics and self-awareness, and the expansion of the strategic metacognitive dimension (UNESCO, 2021). Based on this background, this article is formulated to answer two main research questions: What key dimensions should form a new learning taxonomy that is responsive to the presence of AI as a cognitive partner in primary education, and how can the positioning of AI in this new taxonomy transform the role of teachers, student learning experiences, and the assessment paradigm in primary schools?

2. METHODS

2.1. Research Design

This study employs a conceptual research design utilizing theoretical analysis and systematic conceptual synthesis. The research methodology is structured to develop a comprehensive learning taxonomy through critical examination and integration of existing theoretical frameworks, with particular emphasis on addressing the emerging challenges posed by artificial intelligence in educational contexts. The analytical framework incorporates multiple iterative phases designed to ensure both theoretical robustness and practical applicability in primary education settings.

2.2. Data Sources and Selection Criteria

The investigation draws upon comprehensive academic literature from reputable international journals, scholarly books, and policy documents from authoritative organizations including UNESCO, OECD, and other educational research institutions. Systematic literature searches were conducted across multiple academic databases including Google Scholar, ERIC, Scopus, and Web of Science using carefully selected search terms: "learning taxonomy," "Artificial Intelligence in education," "21st-century skills," "primary education," "Bloom's taxonomy revision," "connectivism in digital age," "AI ethics education," and "human-AI collaborative learning." The selection criteria prioritized peer-reviewed publications from the last decade (2014-2024) to ensure contemporary relevance, while strategically including seminal foundational works essential for understanding the historical evolution of learning taxonomies and educational theory development.

2.3. Data Analysis Procedure

The data analysis followed a systematic four-stage procedure employing multiple analytical approaches. First, critical comparative analysis was conducted to examine established learning taxonomies (Bloom, Anderson & Krathwohl, Marzano) through constant comparison method, identifying both their enduring strengths and fundamental limitations in addressing AI-mediated learning environments. Second, theoretical synthesis analysis was performed by examining 21st-century learning theories (Social Constructivism, Connectivism) alongside contemporary AI education literature, using thematic coding to identify convergent and divergent concepts relevant to human-AI collaborative learning. Third, gap analysis and dimensional mapping utilized axial coding techniques to systematically identify theoretical voids and conceptual spaces where new taxonomic dimensions could be developed, focusing specifically on human-AI interaction patterns and ethical considerations. Finally, conceptual modeling and validation involved iterative refinement of the proposed taxonomic dimensions through mental modeling exercises, ensuring internal coherence and practical applicability through hypothetical test cases in primary education scenarios. This comprehensive analytical approach ensured the development of a robust, multi-dimensional taxonomy grounded in both theoretical foundations and practical educational needs.

3. RESULT AND DISCUSSION

Based on a critical synthesis of the literature, this study results in a proposal for a multi-dimensional learning taxonomy for primary education in the AI era. This taxonomy consists of three interconnected and mutually reinforcing dimensions

3.1. Dimension 1: Cognitive-Metacognitive (The Thinking Dimension)

This dimension is an expansion and recontextualization of Anderson & Krathwohl's (2001) taxonomy, placed within the context of collaboration with AI. Its focus is on strengthening students' independent thinking abilities while strategically leveraging AI. At the level of Remembering & Understanding with AI, students use AI as a sophisticated information search assistant, but they engage in verifying facts from other sources. At the level of Applying & Analyzing with AI, students use AI to apply formulas or analyze texts, but they must be able to check the procedural correctness and analytical logic generated by the AI. A new critical level that forms the backbone of this dimension is Evaluating AI Output, where students systematically assess the quality, bias, accuracy, and relevance of AI-generated content (Zhai et al., 2021). The highest level, Designing Strategy & Creating with AI, involves the use of metacognition to plan and manage the learning process with

AI, where students transition from "users" to "architects" using AI as one of their tools (Su & Yang, 2022). For example, a group of students plans the creation of a presentation on global warming using AI to generate outline ideas and data visualizations, but they themselves compose the narrative, select the most effective visuals, and deliver the presentation with confidence.

3.2. Dimension 2: Human-AI Interaction (The Relational Dimension)

This is a new dimension that is the heart of this taxonomy, mapping the development of competencies in relating to AI as a partner. Its basic level is Prompting, which involves the ability to communicate effectively with AI, evolving from simple to complex and specific prompts (Ng et al., 2021). The next level is Interpreting, where students do not just read AI output but actively interpret it, identify weaknesses, and connect it to prior knowledge. At the Curating level, students use AI to generate a large amount of information or ideas, then actively sort, organize, synthesize, and sequence them to create a coherent product or argument. The highest level of the relational dimension is Co-Creating, a true partnership relationship where students and AI engage in an iterative process to create something new through cycles of prompting, evaluation, and feedback. A student, for instance, might engage in co-creation by writing a story draft, using AI for character development suggestions, revising the draft, and using AI to generate illustrations based on the refined descriptions, resulting in a complete digital storybook as a collaborative work.

3.3. Dimension 3: Ethics and Digital Self-Awareness (The Ethical Dimension)

This dimension integrates critical digital literacy and ethical considerations into the core of the learning process. It begins with Digital Self-Awareness, where students are aware of their digital footprint and how their data can be used by AI systems. The next level is Recognizing Algorithmic Bias, where students learn that AI can inherit and amplify social biases and are trained to critically question the perspectives present and missing in AI output (O'Neil, 2016). Then, at the Ethical and Social Consideration level, students discuss the social impact of AI on employment, social relationships, and democracy. The highest level is Agency and Accountability, the understanding that humans retain full agency and accountability for outcomes produced with AI, a key differentiator between humans and machines (Dignum, 2019; UNESCO, 2021).

3.4. Critical Implications for Theory and Practice

The proposed multi-dimensional taxonomy adds significant value by explicitly mapping the new cognitive-relational-ethical landscape, thereby addressing Connectivism's critique of the limitations of individual-focused older models (Siemens, 2017). The adoption of this taxonomy would radically transform the teacher's role from knowledge source to ethical guide, learning experience architect, and metacognition facilitator. Teachers need to develop **AI-Pedagogical Content Knowledge (AI-PCK)**, an adaptation of the TPACK framework (Mishra & Koehler, 2006), which is a deep understanding of how to use AI to teach specific content in a developmentally appropriate way while promoting critical and ethical skills (Chiu, 2023). This transformation also requires a fundamental evolution in the assessment paradigm, from measuring fact recall to assessing process and competencies, for example through processfolios documenting students' interaction history with AI, performance assessments, and project-based assessments (Zhai et al., 2021). However, its implementation faces major challenges such as the digital divide that can widen inequalities, the massive need for teacher training, and

the risk of over-reliance on AI. In response to the criticism that this taxonomy is too complex, it can be argued that the approach must be developmental and gradual, introducing AI consciously and critically according to student maturity (Su & Yang, 2022).

4. CONCLUSION

This article has presented a critical argument that the transformative integration of AI in primary education requires a reconfiguration of our conceptual framework of learning and knowing. Traditional learning taxonomies, while still valuable as a foundation, have reached their limits in facing the reality where intelligence is no longer a human monopoly. The proposed multi-dimensional taxonomy—encompassing the Cognitive-Metacognitive, Human-AI Interaction, and Ethics dimensions—offers a roadmap for navigating this new landscape by positioning AI as a powerful cognitive partner that, when managed appropriately, can deepen and enrich the learning experience. The ultimate value of this taxonomy lies in its commitment to developing unique and irreplaceable human capabilities—such as empathy, authentic creativity, ethical judgment, and wisdom—in symbiosis with machine capabilities. To realize this, recommendations are proposed for researchers to further test and validate this taxonomy, for curriculum developers to design learning materials that train human-AI interaction skills, and for teacher training institutions and policymakers to prioritize teacher training in AI-PCK and ensure equitable access and clear ethical guidelines (UNESCO, 2021; Chiu, 2023). With these strategic steps, primary education can shift from a reactive to a proactive position in shaping a future where technology empowers our most fundamental humanity.

REFERENCES

Anderson, L. W., & Krathwohl, D. R. (Eds.). (2001). *A taxonomy for learning, teaching, and assessing: A revision of Bloom's taxonomy of educational objectives*. Longman.

Baker, R. S. (2016). Stupid tutoring systems, intelligent humans. *International Journal of Artificial Intelligence in Education, 26*(2), 600-614.

Bloom, B. S., Engelhart, M. D., Furst, E. J., Hill, W. H., & Krathwohl, D. R. (1956). *Taxonomy of educational objectives: The classification of educational goals. Handbook I: Cognitive domain*. David McKay Company.

Chiu, T. K. F. (2023). The impact of Generative AI (GenAI) on practices, policies and research direction in education: A case of ChatGPT and Midjourney. *Interactive Learning Environments*, 1-17.

Dignum, V. (2019). *Responsible artificial intelligence: How to develop and use AI in a responsible way*. Springer.

Hwang, G. J., Xie, H., Wah, B. W., & Gašević, D. (2020). Vision, challenges, roles and research issues of Artificial Intelligence in Education. *Computers and Education: Artificial Intelligence, 1*, 100001.

Kasneci, E., Seßler, K., Küchemann, S., Bannert, M., Dementieva, D., Fischer, F., ... & Kasneci, G. (2023). ChatGPT for good? On opportunities and challenges of large language models for education. *Learning and Individual Differences, 103*, 102274.

Luckin, R. (2018). *Machine learning and human intelligence: The future of education for the 21st century*. UCL Institute of Education Press.

Marzano, R. J., & Kendall, J. S. (2007). *The new taxonomy of educational objectives* (2nd ed.). Corwin Press.

Mishra, P., & Koehler, M. J. (2006). Technological pedagogical content knowledge: A framework for teacher knowledge. *Teachers College Record, 108*(6), 1017-1054.

Ng, D. T. K., Lee, M., Tan, R. J. Y., Hu, X., Downie, J. S., & Chu, S. K. W. (2021). A review of AI teaching and learning from 2000 to 2020. *Education Research Review, 100091*.

O'Neil, C. (2016). *Weapons of math destruction: How big data increases inequality and threatens democracy*. Crown Publishing Group.

Roll, I., & Wylie, R. (2016). Evolution and revolution in artificial intelligence in education. *International Journal of Artificial Intelligence in Education, 26*(2), 582-599.

Siemens, G. (2005). Connectivism: A learning theory for the digital age. *International Journal of Instructional Technology and Distance Learning, 2*(1), 3-10.

Siemens, G. (2017). Connectivism: A learning theory for the digital age. In *Foundations of learning and instructional design technology*. EdTech Books.

Su, J., & Yang, W. (2022). Artificial intelligence in early childhood education: A scoping review. *Computers and Education: Artificial Intelligence, 3*, 100049.

UNESCO. (2021). *AI and education: Guidance for policy-makers*. United Nations Educational, Scientific and Cultural Organization.

Woolf, B. P. (2010). *Building intelligent interactive tutors: Student-centered strategies for revolutionizing e-learning*. Morgan Kaufmann.

Zhai, X., Chu, X., Chai, C. S., Jong, M. S. Y., Istenic, A., Spector, M., ... & Li, Y. (2021). A review of artificial intelligence (AI) in education from 2010 to 2020. *Complexity, 2021*, 1-18.

.